

**PATENT APPLICATION**

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Title: **COMBUSTOR LINER V-BAND DESIGN**

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## COMBUSTOR LINER V-BAND DESIGN

### RELATED APPLICATION

[0001] This application is a continuation-in-part of United States Serial No 10/357,363, now United States 5 Patent No \_\_\_\_\_.

### TECHNICAL FIELD

[0002] The invention relates to a combustor liner v-band louver, which may be manufactured of cast segments and removably fastened to the combustor liner.

### BACKGROUND OF THE ART

[0003] Gas turbine engine combustors are relatively thin sheet metal shells surrounded by a plenum containing compressed air from the compressor. Air flows into the combustor through the fuel nozzles to mix with the fuel and 15 through several small openings or louvers in the combustor liner wall which create an air curtain along the inside surface of the combustor liner, provide further air for combusting the fuel and create circulation currents of gas and air flowing within the combustor.

[0004] Conventional combustors may include circumferential V-shaped bands machined into inner wall surfaces that protrude into the combustor from the liner surface or sheet metal double band louver, to generate single or double toroidal fluid flow in the primary 20 combustion zone. In an annular combustor the toroidal

flow increases gas residence time in the combustor and thereby improves the fuel/air mixing, engine efficiency and reduces emission levels.

[0005] Conventional so-called machined V-band louvers as well double band sheet metal louvers protrude into the hot gas path and are exposed to a harsh environment of rapidly flowing hot gases which tend to oxidize the metal liner material.

[0006] A particular disadvantage of conventional machined V-band or standard double band sheet metal louvers circumferential louvers is the development of axial cracks due to the high hoop stresses resulting from temperature differentials. Thermal expansion and contraction stresses exerted on the louver together with the high temperatures expose these protruding components of the combustor wall to durability problems including cracking and oxidation.

[0007] Further, V-band louvers or other similar machined louvers are very expensive to manufacture and often require repair during engine overhauls. Conventional combustor liner designs however incorporate the V-band louvers in the unitary machined structure of the combustor liner, and so repair is required to the liner itself.

[0008] It is an object of the present invention to provide a more cost effective means of generating the single or double toroidal flow in the primary zone of the combustor liner.

[0009] It is a further object of the invention to reduce or eliminate the high hoop stresses in the combustor liner

which promote the development of axial cracks in the prior art.

**[00010]** It is a further object of the invention to reduce the cost of manufacture and repair of a combustor liner.

5 **[00011]** Further objects of the invention will be apparent from review of the disclosure, drawings and description of the invention below.

**DISCLOSURE OF THE INVENTION**

10 **[00012]** The invention provides a method of making a gas turbine engine combustor using the steps of: providing a combustor; providing a circumferentially extending louver member for ducting a flow of compressed air through at least one inlet opening in a combustor wall from a source of compressed air outside the combustor; and mounting the 15 louver member in a non-destructive manner for releasable connection and disconnection to an interior surface of the combustor wall and at least partially covering the at least one inlet opening, the louver having a number of outlet openings in flow communication with an inlet opening.

20 **[00013]** As in the prior art, the primary function of the machined V-band/sheet metal double band louver is to generate single or double toroidal flow pattern in the combustor liner to promote fuel combustion efficiency, increase residence time and reduce emissions. However the 25 invention permits reduction in machining required to create the toroidal flow inducing feature in the combustor liner, easing the assembly due to bolted construction and permitting repair or replacement of only the damaged

sections through use of separate segments to assemble a circumferential band member about the combustor liner wall.

[00014] A benefit of the segmental construction is the reduction of hoop stresses and increasing of the fatigue 5 life of the V-band. Prior art designs induce significant hoop stresses due to the unitary annular structure when exposed to temperature differentials or fluctuations. By creating separate, preferably cast, segments which are assembled together to form the circumferential louver 10 assembly, with a circumferential expansion and contraction joint between adjacent pairs of segments, hoop stresses and axial cracking due to thermal expansion and contraction can be reduced.

[00015] In addition, the segmental construction permits a 15 higher degree of assembly and manufacturing tolerance and permits the segments to be manufactured of metals or other materials which have different oxidation or other characteristics and different fatigue strength than the combustor liner to which they are releasably fastened in a 20 non-destructive manner. The interior channels and outlets of the louver can be easily inspected for corrosion or damage by removing modular segments from the combustor wall. A segmented cast metal construction is more cost effective to manufacture than conventional designs due to 25 reduced machining, and assembly is simplified by the bolted connection. These features result in lower cost operation since oxidation damaged sections can be replaced individually in a simple bolted connection.

[00016] A further advantage of the invention is the diversion of any leakage between the cast V-band segment and the section of the combustor liner wall to which it is releasable attached. Leakage of air through any gap 5 between the cast V-band segment and the combustor liner forms a beneficial film or curtain cooling layer adjacent the liner in the immediate local area.

**DESCRIPTION OF THE DRAWINGS**

[00017] In order that the invention may be readily 10 understood, embodiments of the invention are illustrated by way of example in the accompanying drawings.

[00018] Figure 1 is an axial cross-sectional view through a turbofan gas turbine engine showing a general arrangement of components including the location of combustor.

15 [00019] Figure 2a is an axial cross-sectional view through a combustor liner showing an inner and an outer V-band of conventional prior art design. Figure 2b shows a cross section view of a sheet metal double band louver also of conventional prior art design.

20 [00020] Figures 3-8 show a first embodiment of the invention, where Figure 3 shows the separate cast metal combustor wall louver band mounted with threaded studs to the interior surface of the combustor wall.

25 [00021] Figure 4 is a detailed view of the louver shown in Figure 3.

[00022] Figure 5 is a partial isometric view of the outer combustor with inlet openings and louver bands with threaded studs for mounting purposes.

5 [00023] Figure 6 is an interior isometric view of the combustor wall louver.

[00024] Figure 7 is an outer view of a combustor wall louver segment showing three threaded studs and the interior channel with outlet openings.

10 [00025] Figure 8 is an interior isometric view of the combustor wall louver segment shown in Figure 7.

[00026] Figure 9 is an axial cross sectional view through a prior art reverse flow combustor liner.

15 [00027] Figure 10 is a like axial sectional view through a reverse flow combustor liner with segmented louver (according to a second embodiment) mounted to the combustor liner with threaded studs.

[00028] Figure 11 is an interior isometric view of the combustor wall louver segment mounted to the combustor liner wall with threaded studs.

20 [00029] Figure 12 is a side isometric view of a combustor wall louver segment showing internal channel with outlet openings and threaded studs for mounting to the combustor wall.

25 [00030] Further details of the invention and its advantages will be apparent from the detailed description included below.

**DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

[00031] Figure 1 shows an axial cross-section through a typical turbofan gas turbine engine. It will be understood however that the invention is equally applicable to any 5 type of engine with a combustor such as a turbo-shaft, a turboprop, auxiliary power unit, gas turbine engine or industrial gas turbine engine. Air intake into the engine passes over fan blades 1 in a fan case 2 and is then split into an outer annular flow through the bypass duct 3 and an 10 inner flow through the low-pressure axial compressor 4 and high-pressure centrifugal compressor 5. Compressed air exits the compressor 5 through a diffuser 6 and is contained within a plenum 7 that surrounds the combustor 8. Fuel is supplied to the combustor 8 through fuel tubes 9 15 which is mixed with air from the plenum 7 when sprayed through nozzles into the combustor 8 as a fuel air mixture that is ignited. A portion of the compressed air within the plenum 7 is admitted into the combustor 8 through orifices in the side walls to create a cooling air curtain 20 along the combustor walls or is used for cooling to eventually mix with the hot gases from the combustor and pass over the nozzle guide vane 10 and turbines 11 before exiting the tail of the engine as exhaust. It will be understood that the foregoing description is intended to be 25 exemplary of only one of many possible configurations of engine suitable for incorporation of the present invention.

[00032] Figure 2a and 2B show a detailed axial cross sectional view through a combustor 8 with a prior art integral machined V-band or sheet metal double band louver 30 15. The fuel supply tube 9 is shown, however the fuel

nozzle arrangement has not been shown, for simplicity. The inner combustor wall 12 and outer combustor wall 13 are joined with a bolted connection 14. Of interest to the present invention, the outer combustor wall 13 includes a 5 conventional prior art integral V-band louver 15 that admits air from the plenum 7 into the interior of the combustor 8 to create a toroidal flow of fuel/air mixture within the combustor dome 16, as indicated with arrows in Figure 2.

10 [00033] Figure 3 shows a detailed view of the outer combustor wall 13 with flanged connection 14. In accordance with the invention, a combustor wall louver 15 comprising a circumferentially extending band member 17 is releasably mounted to the interior surface of the combustor 15 wall 13 and covers a series of inlet openings 18 (which are best seen in Figure 5). Compressed air flows through the inlet openings 18 in the combustor wall 13 from the surrounding plenum 7.

20 [00034] The band 17 includes a large number of laterally extending outlet openings 19 (best seen in Figure 6). The circumferentially extending band 17 is mounted to the interior surface of the combustor wall 13 with threaded studs 20 through openings. The generally V-shaped band 17 preferably includes a central channel 21 in flow 25 communication with each outlet opening 19 and with the inlet openings 18.

[00035] In the first embodiment shown in Figures 3-8, the band 17 includes an inner circumferential surface 22 which protrudes into the interior of the combustor 8 and is

exposed to hot gas flow. In order to provide cooling, the inner circumferential surface 22 preferably includes thumb nail cooling air openings 23 communicating with the channel 21 through radial bores 24. As shown in Figures 6 and 8,  
5 the cooling air openings 23 are preferably disposed in an inward spirally directed cooling vent 25.

**[00036]** As best seen in Figures 7 and 8, preferably, the circumferentially extending band 17 is made of a number of arcuate segments 26, each removably mounted to the interior 10 surface of the combustor wall 13 with threaded studs 20. The segments 26 of the circumferentially extending band 17 have combustor wall abutting edges 27 bounding the air flow channel 21. Each segment 26 (shown in Figures 7 and 8) includes two combustor wall abutting end bulkheads 28 which 15 circumferentially contained the compressed air within the channel 21 to flow out into the combustor through outlet openings 19 and through cooling air openings 23 via bores 24.

**[00037]** In the first embodiment (shown in Figures 3 to 8) 20 the combustor wall 13 has a recessed groove. The combustor wall abutting edges 27 of the circumferential band 17 engage the recessed groove 29 in a generally close fitting manner in order to ensure that the bulk of compressed air progresses through inlet openings 18 and out through outlet 25 openings 19 or through bore 24. However as indicated in Figure 4, a certain amount of leakage may escape through an air curtain gap defined between the interior surface of the combustor wall 13 and the combustor wall abutting edges 27 of the louver 17 to create a beneficial cooling air film or 30 curtain. To simplify manufacture and assembly, as well as

reduce stress concentration, the recessed groove has sloped side walls and a circumferential bottom wall into which the inlet openings 18 are provided (in Figure 4).

[00038] The remaining Figures 10 through 12 illustrate a 5 second embodiment of the invention applied to replace the V-band louver 15 of a prior art reverse flow combustor 8 shown in Figure 9. In the prior art arrangement illustrated in Figure 9, the V-band groove 15 is disposed in the outer combustor wall 13 which is connected to the 10 inner combustor wall with the dome 16. The fuel nozzles and fuel supply tubes are omitted for clarity.

[00039] Figure 10 illustrates the replacement of the V-band louver 15 with a circumferentially extending band 17 mounted to the interior surface of the outer combustor wall 15 13 and covering inlet openings 18 in a manner similar to that described above in respect of the first embodiment. However, as best shown in Figures 11 and 12, the segments 26, that are assembled into a circumferentially extending band 17, are mounted flush with the internal surface of the 20 combustor wall 13 (not in a groove 29 as the first embodiment). The flush mounting arrangement somewhat simplifies machining, assembly and manufacture, and its use is not dictated by the combustor configuration.

[00040] As best seen in Figure 11, the threaded studs 25 extend from the band 17 through the combustor wall 13 with removable nuts 30 externally fastened to the studs 20. Vents 25 and laterally extending outlet openings 19 expel air jets as described above in relation to the first embodiment. As seen in Figure 12 however, the bulkheads 28

also include at least one outlet opening 19 for cooling and purging hot gases from the area between abutting segments 26.

[00041] It will be appreciated from the above description 5 and particularly Figure 7, 8 and 12, that each segment 26 can be easily manufactured as a shallow arcuate metal casting which may require minimal machining to meet tolerances or form the outlet openings 19 for example. The 10 studs 20 in Figure 7 extend from a raised boss 31 within the channel 21. The boss 31 reinforces the local area but does not significantly impede the free flow of compressed air through the channel 21.

[00042] Although the above description relates to a specific preferred embodiment as presently contemplated by 15 the inventors, it will be understood that the invention in its broad aspect includes mechanical and functional equivalents of the elements described herein. It will also be understood that certain changes will also be apparent to those skilled in the art which may be made to the disclosed 20 embodiments without departing from the invention described herein. For example, the invention may be applied to any combustor in which a V-band may beneficially produce a toroidal flow. The invention may be fastened to a combustor by any suitable means. Furthermore, the 25 invention need not be cast but other suitable fabrication means may be employed. Still other changes will be apparent to those skilled in the art, and it is understood that such changes do not depart from the scope of claims below.